SEMI-ANNUAL REPORT
NASA CONTRACT NAS5-31368
FOR MODIS TEAM MEMBER STEVEN W. RUNNING
ASSOC. TEAM MEMBER RAMAKRISHNA R. NEMANI
SOFTWARE ENGINEER JOSEPH GLASSY
Jan 15, 1997

PRE-LAUNCH TASKS PROPOSED IN OUR CONTRACT OF DECEMBER 1991

We propose, during the pre-EOS phase to: (1) develop, with other MODIS Team Members, a means of discriminating different major biome types with NDVI and other AVHRR-based data. (2) develop a simple ecosystem process model for each of these biomes, BIOME-BGC based on the logic of the current FOREST-BGC; (3) relate the seasonal trend of weekly composite NDVI to vegetation phenology and temperature limits to develop a satellite defined growing season for vegetation; and (4) define physiologically based energy to mass conversion factors for carbon and water for each biome.

Our final core at-launch product will be simplified, completely satellite driven biome specific models for ET and PSN based on this modified ∑NDVI logic. These algorithms will be in MODISDIS before launch. We will build these biome specific satellite driven algorithms using a family of simple ecosystem process models as calibration models, collectively called BIOME-BGC, and establish coordination with an existing network of ecological study sites in order to test and validate these products. Field datasets will then be available for both BIOME-BGC development and testing, use for algorithm developments of other MODIS Team Members, and ultimately be our first test point for MODIS land vegetation products upon launch. We will use field sites from the National Science Foundation Long-Term Ecological Research network, and develop Glacier National Park as a major site for intensive validation.

OBJECTIVES:

We have defined the following near-term objectives for our MODIS contract based on the long term objectives stated above.

- Organization of an EOS ground monitoring network with collaborating U.S. and international science agencies.
- Develop advanced logic for landcover classification using carbon cycle simulations from BIOME-BGC.
- Develop improved algorithms for estimating LAI and FPAR for different biome types from AVHRR data.
- Test of a generalized ecosystem process model, BIOME-BGC, for the simulation of the carbon, water and nitrogen cycles for different biomes.
- Implementation of the Global Ecological Simulation System (GESSys) to estimate continental net primary production (NPP) and ε for the globe.
- Finish formal software engineering of our MODIS products, #14 Leaf Area Index and Fraction Absorbed Photosynthetically Active Radiation, and Daily Photosynthesis - Annual Net Primary Production, #16 and 17.

The NTSG lab currently employs the following members who contribute to certain aspects of our MODIS work. :

Dr. Steven Running, Director and Professor,
Dr. Ramakrishna Nemani, Research Assoc. Professor
Dr. LLoyd Queen, Associate Professor
Dr. John Kimball, Postdoctoral Research Associate
Dr. Kathy Hibbard, Postdoctoral Research Associate
Mr. Joseph Glassy, Software Engineer
Mr. Saxon Holbrook, Computer Systems engineer
Mr. Peter Thornton, PhD student
Mr. Joe White, PhD student
Ms. Galina Churkina, PhD student
Mr. Mike White, PhD student
Mr. Geoff Poole, PhD student
Mrs. Debra Kendall, Office Manager

WORK ACCOMPLISHED:

Our core MODIS Team now consists of SWRunning, Team Member, R. Nemani, Associate Team member, and Joe M. Glassy, Software Engineer. Dr. Lloyd Queen has recently joined the faculty and our NTSG group, and is being supported by MODIS funds to develop advanced regional scale resource applications from our standard MODIS products. The following will be reports on individual activities during this reporting period.

ACTIVITIES OF SWRunning - Team Member, JULY 1996 - JANUARY 1997

EOS-IWG

As Chair of the EOS Land Science panel, SWR completed Chapter 7, Land Ecosystems and Hydrology for the EOS Science Plan. The text can be found on the Land Panel homepage, hosted by our lab at:

http://150.131.101.6:80/ntsg/projects/global/EOS_land/

EOS-USFS FIRE ANALYSIS

A wildland fire analysis system is being proposed in collaboration with the USFS (Figure 1), integrating several EOS products with surface weather observations. The comprehensive system to be developed at NTSG/U. Of Montana will be the first in the nation addressing a suite of fire related issues that cost the nation over a billion dollars each year.

EOS VALIDATION

My central objective now is to organize a logical and efficient validation plan for EOS Land science, of which the MODLAND variables are central. During the last half-year I have tried to evolve the idea of a Simple Integrated Tower Concept, which could take critical validation data for remote sensing, atmospheric corrections, surface meterology and terrestrial ecology variables. I have given the following summary to IGOS and EOS meetings:

SIMPLE INTEGRATED TOWER CONCEPT

	VARIABLE DEPENDENCIES			
	EB	ATM	BRDF	TG
COMPONENT TOWER VARIABLES				
-ENERGY BUDGET/SURFACE METEOROLOGY (EUROFLUX, FLUXNET ETC)	O	X	X	-
-ATMOSPHERIC CORRECTIONS, AEROSOLS (SHADOW-BAND RADIOMETER)	X	O	X	-
-BIDIRECTIONAL SPECTRAL RADIANCES (SUN PHOTOMETER)	X	X	O	-
-TRACE GAS FLUXES/CONCENTRATIONS (CARBON AMERICA, TRAGNET ETC)	X	X	X	O
FOOTPRINT (100KM^2) VEGETATION ANALYSIS				
-LANDCOVER	X	X	X	X
-LAI/FPAR	X	X	X	X
-NET PRIMARY PRODUCTION	X	X	X	X
-STEM AND SOIL BIOMASS	X	X	X	X

I consider this a very efficient plan for organizing one aspect of EOS validation around.

EOS-NSF/LTER

A joint proposal to NASA and the National Science Foundation was selected for start-up funding to explore sampling and instrument methodologies for measuring 3 MODIS core products, landcover, LAI and NPP over multi-hundred kilometer areas. This is a key activity in our MODLAND validation strategy. An organizing workshop on this project was held at the HJAndrews LTER in Oregon. A comprehensive proposal

for validating MODIS core products is being prepared in response to the validation AO. The meeting summary follows:

'MODIS Land Science Team & Long-Term Ecological Research Network Synthesis (MODLERS) project summary.

This project brings together 14 Long-Term Ecological Research (LTER) Network sites and NASA's MODIS Land (MODLAND) Science Team for the purpose of locally validating Earth Observation System-era global data sets. Using several standardized methods that incorporate extensive ground data sets, ecosystem models, and remotely-sensed imagery, each LTER site is developing local maps of landcover class, leaf area index, and aboveground net primary productivity for a 100 km2 area at a grain size of 25 m. A nested, hierarchical ground-based sampling scheme will help establish error bounds on the variable estimates. A number of different strategies are being used to spatially aggregate the fine-grain site maps to a coarse grain (1 km) so that they can be compared to coincident portions of global maps of the same three biosphere variables developed by the MODLAND Science Team. This coordinated, multi-site grain-size aggregation exercise presents us with an opportunity to grapple with one of the most vexing current problems in ecology: effects of scaling from a fine grain to a coarse grain on estimates of important biosphere variables. We are using several spatially-explicit, geostatistical methods to address this issue, with the intent of determining how best to maintain crucial information among grain sizes. Additionally, we are characterizing similarities and differences among the multiple sites and biomes and between the MODLAND maps and the site maps at each grain size, in terms of the three mapped biosphere variables. For more information visit our web site at

http://atlantic.evsc.virginia.edu/~jhp7e/modlers/

MODLERS Project bullets:

* Structured into 7 working groups--1) technical remote sensing, 2) LAI/NPP field measurements, 3) land cover mapping, 4) spatial aggregation, 5) cross-site comparison, 6) data management, and 7) communications

* Technical remote sensing is the resource groups for spectral vegetation indices, atmospheric corrections, etc.

* LAI/NPP measurements is describing methods from literature to help determine best methods for estimates across the network, and for designing sampling strategy

* land cover mapping responsible for defining land cover schemes and translations among schemes, and for definition of accuracy assessment standards

* spatial aggregation will conduct standard aggregation of all 25 m data layers to 1 km

* cross-site is for comparing models and methods across sites, for comparing sites at all aggregation levels, and for integrating resluts with MODLAND

* data management is to facilitate ready availability of data sets needed by MODLERS and, ultimately, outside users

* communications is where our web-page activity is

Most important issues were addressed and solutions derived at the workshop. We are preparing written material for peer-review, and for submission as a special issue to journal. By end of calendar year we plan to have several ms. ready for submission, will have some results on LCC map aggregation, and will have existing LAI/NPP data organized and ready to use.

NSF - National Center for Ecological Analysis and Synthesis

SWR was selected for the Scientific Advisory Board of the newly NSF funded NCEAS. This center can play a significant role in organizing terrestrial research data for EOS science, and should play a useful role in the EOS Validation Plan. The homepage is at:

http://www.ceas.ucsb.edu/

Global Climate and Terrestrial Observing Systems (GCOS/GTOS)

SWR has been appointed to the Terrestrial Observation Panel for Climate, TOPC, planning a joint Global Climate and Global Terrestrial Observing System (GCOS-GTOS) Terrestrial Observing System. SWR attended an IGOS (Integrated Global Observing System) meeting to plan a strategy for synergism amongst the Global Climate, Terrestrial and Ocean Observing Systems.

VEMAP - Vegetation ecosystem modeling and analysis project

VEMAP is a project to intercompare leading biogeography and biogeochemistry models in the US for global change and EOS research programs. VEMAP has a homepage at:

http://www.cgd.ucar.edu:80/vemap/

The BIOME-BGC model that is part of our MODIS algorithm development for our NPP product is one of the three biogeochemistry models being tested. The other two models are from the Moore and Schimel EOS/IDS teams. The first VEMAP paper has been published in the December 1995 issue of Global Biogeochemical Cycles, and is attached.

IGBP Biospheric Aspects of the Hydrologic Cycle (BAHC)

As a member of the Science Steering Committee for BAHC, SWR has been involved with writing the Science Plan for BAHC Focus 1, and planning the science agenda for 5 years now. SWR is working with Drs Dennis Baldocchi and Ricardo Valentini concerned with organizing a global network of CO_2 and H_20 flux towers for continuous validation of MODLAND vegetation flux products. This network called FLUXNET, is based on the La Thuile, Italy workshop, and was published in Global Change Biology, in June 1996, reprint attached. FLUXNET is a precursor to the EOS Simple Tower Concept I am working on.

Carbon-America

A new activity is being organized to design an atmospheric measurement system for the continental US as a validation source for Earth Systems Models and EOS measurements. This activity is being discussed on the Internet, being called Carbon-America, and is led by Dr. Pieter Tans from NOAA in Boulder,CO. This is a related activity to tower networks that in my mind needs to be integrated into a larger single network plan, which I will work on in the coming months.

PIK NPP Workshop

The IGBP-GAIM project is running a global NPP model intercomparisons at the Potsdam Institute for Climate change in Potsdam, Germany. This activity is the most organized effort in the world to determine best NPP analysis for validating the MODLAND NPP product. Steve Prince is leading an activity to build a global database of published NPP measurements. Galina Churkina and SWR are writing a paper analyzing the water balance control logic of the PIK-NPP models, and a second paper on the multiple environemental controls of NPP expressed in our BIOME-BGC model.

GAP Analysis Project

The GAP analysis project is a US National Biological Service funded project to map wildlife habitat in each state using high resolution satellite imagery. Their homepage is at:

http://www.gap.uidaho.edu/gap/

I am working with the national GAP office about sharing their database with the MODLAND team to use as a validation source for our Landcover algorithm. Details of this agreement are being developed.

NASA EOS MEETINGS ATTENDED (SWR)

MODIS Science Team Meeting, October 1996
National Center for Ecological Analysis and Synthesis, Board of Directors meeting, October 1996
EOS-SEC Meeting, September 1996
EOS-SEC Meeting, December 1996,
MODIS ATBD Review December, 1996

ACTIVITIES OF R. NEMANI - MODLAND

Objectives:

My objectives were to update the ATBDs for the two MODIS products (MOD15 and MOD17). Generate a back-up algorithm for estimating LAI/FPAR from MODIS reflectances. Test BIOME-BGC model with various ground based observations and then use it to produce production efficiency factors for various combinations of climate and vegetation.

WORK ACCOMPLISHED

MOD15 LAI/FPAR

ATBD revisions

Extensive revisions were made to the MOD15 ATBD, in preparation for the review in December 1996. We actively collaborated with Dr. Myneni (New MODIS Team member) and submitted a joint ATBD describing the LAI/FPAR product. The algorithm in its present form has two modes: a) VI based empirical estimates of LAI/FPAR, b) a Look-Up-Table based MODIS/MISR synergistic algorithm that uses reflectances from both MODIS and MISR sensors.

VI based backup algorithm

As a fail-safe method for producing LAI/FPAR product, we designed a simple VI based algorithm based on the results of 3-D RT model developed by Dr. Myneni. The RT model was run for a number of combinations of input parameters such as biome type, soil background, ground cover, sun and view angles. The results from this analysis were used to create a bank of relationships describing the relation between

VI and LAI/FPAR. Based on the ancillary data (biome type, soils and ground cover etc.), one of the relationships could be used to generate the LAI/FPAR product.

Using the AVHRR/Pathfinder 8 km data, we generated monthly surfaces of LAI and FPAR for 10 years (Figures 2 and 3). Currently, the LAI/FPAR data are being tested for consistency and accuracy over different vegetation types. Further, these data are being used as input to our PSN/NPP algorithm.

LUT Approach to estimating LAI/FPAR

In order to take full advantage of the synergy between MODIS and MISR, a Look_Up-Table based approach is being developed. Using 3-D RT model, we have generated reflectances compatible with MODIS and MISR sensors for various combinations of land surface parameters and sensor geometry. Currently we are working on optimum methods for extracting best estimates of LAI/FPAR from the LUT. This approach will be operational after extensive testing is done with actual reflectance data from MODIS and MISR.

MOD17 PSN/NPP Algorithm

This algorithm is based on Production Efficiency Models widely used with remotely sensed data. To produce the efficiency factors for various combinations of climate, vegetation, we are using our BIOME-BGC model. We are testing the BIOME-BGC model with several ground based observations collected around the world. Once the tests are complete, we will produce the efficiency factors that would go into the MOD17 algorithm. Work is also in progress for estimating standing biomass, which is important for estimating respiration losses from terretrial vegetation.

A coarse resolution map of the factors (water, nutrients and radiation) limiting NPP was developed (Figure 4). This map will be useful to identify key variables in the algorithm that need to be quantified accurately over different parts of the globe.

MEETINGS ATTENDED

MODIS Science meeting, October 1996, Washington, D.C.
MODIS Land cover Meeting, November 1996, Boston

ACTIVITIES OF J.M. GLASSY, UM SCF MODIS SOFTWARE ENGINEER

OBJECTIVES

My objectives during the time period October 1996 and February 1997 were to 1) focus on the implementation changes resulting from the new generation of Algorithm Theoretical Basis Documents (ATBD) for MODIS Land Products MOD15 (FPAR, LAI) and MOD17 (PSN,NPP), and 2) oversee continued development of our Science Compute Facility MODIS Compute Ring at the University of Montana.

WORK ACCOMPLISHED

MOD15: FPAR/LAI Product

The dominant activity during this period focused on algorithm design refinements associated with implementing the revised empirical algorithm method. Coding of the main algorithm for V1 delivery has been delayed somewhat due to complications involving the discretizing of continuous inputs to the keys required by both the formal lookup table and the new 4-day empirical model coefficients lookup table. Delivery of V1 codes is now expected in the late February 1997-early March 1997 timeframe. We are also currently working on the formal definition of the V2 MOD15 V1 File Specification, due to be completed at the end of February 1997. The MODLAND team revised draft Q/A plan was evaluated in cooperation with David Roy, where new team wide Q/A issues were addressed.

MOD17: PSN/NPP Product

On the MOD17 algorithm, a trial daily surface climatology data set obtained from the DAO in GRADS format was formally evaluated, yielding new information on spatial problems in the near surface temperature and humidity fields. These problems were reported to Yong Li of the DAO, who reports they are related to surface roughness threshold behavior of the basic DAO 4DDA assimilation model. The DAO is working on some resolution to these output field problems, which show up predominantly in near-equatorial tropical biomes. The current recommendation DAO has provided us is to consider working with 10m fields, n option we are now investigating. Coding continues on the three main PSN, NPP software modules making of the MOD17 suite: ***clim_psn***, (for temporal aggregation of the DAO climate database), ***psn_npp*** (the main net primary productivity algorithm), and ***aggr_psn*** (the post-processor for spatially degenerating the 1KM outputs to the coarse geographic projection climate modeling grid).

MODIS UM SCF Compute Ring Infrastructure

During this period, our main compute server, an 8-way IBM RS/6000 Model J-30 workstation was upgraded from a 601 CPU based system to a 604 CPU based

system, increasing the performance considerably. The evaluation of the new DEC Alphaserver model 4100 is nearly complete. We are progressing on local network improvements, which include plans for purchasing 100Base T NIC cards for our major compute ring components.

The SCF level MUM application programming interface library (MODIS-Univ.Montana, or MUM) underwent significant improvements in addressing HDF v.4.0r2 facilities and capabilities; these revisions were required for proper ECS metadata handling in the V1 and future codes. For internal development purposes, a revised distributed software compute scheme (Montana Nested Cluster) was prototyped in this period, for exploiting our new SMP hardware. Under this distributed compute architecture, large volume tasks are concurrently distributed across a set of SMP CPUs under the direction of a session monitor. The full MNC scheme will distribute tasks over a set of network connects hosts (uniprocessor as well as SMP computers), as well as to the multiple CPUs present in a given SMP component.

ON GOING ACTIVITIES

MODIS UM SCF Compute Ring Infrastructure

For the near-term period, we are planning on acquiring another 100G of RAID 3/5 disk store, bringing our SCF total to approximately 200G, with another 300G minimum planned to be added in the next year, budget permitting. We are investigating the purchase of a MODIS Compute Ring Specific 4mm DAT/DLT archive store as well for this period.

Activities of Dr. LLoyd Queen:

Presented paper to Montana GIS Conference on the terrestrial science products being developed for surface resistance (drought index) and fire detection, April 1996.

Made 2 presentations to Upper Midwest Aerospace Consortium on the drought/surface resistance products and their applicability to monitoring forest and rangeland condition, January and April 1996.

Signed Research Joint Venture Agreement (RJVA) with the USDA Forest Service Intermountain Fire Sciences Laboratory in Missoula, MT. Project is designed to apply and validate vegetation index, landcover, and drought products for selection and parameterization of fire emissions models. This agreement provides support for a newly recruited PhD student. Student efforts include literature review, development of working partnerships with Team Scientists, work on the RJVA project, and

installation of UNIX image processing and code development system.

Compiling 1994 conterminous AVHRR data set (both daily and 10-day composite) for prototype implementation of resistance and fire detection algorithms=97including workstation setup and EML programming of prototype fire detection algorithm for 1994 data.

Wrote product validation scheme for terrestrial products as a part of the RJVA. This incorporates field samples, development of field fire occurrence reports database, and utilization of multi-platform database (AVHRR, DMSP, and Landsat TM) for cross-comparison.

Reviewed current products and delivery scheme for USFS/IFSL NDVI images. The IFSL currently develops NDVI derivative products (Relative Greenness, Departure Index, and Visual Greenness) that are delivered to Forest Service audiences via the World Wide Web and the Boise Fire Weather Center. MODIS terrestrial science products will supplement the images archived to the Boise Fire Weather Center on-line database. Discussions have also included enhanced delivery via implementation of progressive picture transmission protocol and enhanced user access to data files rather than .gif format picture files.

Similar discussions have transpired with the Montana State Library=92s Natural Resource Information Systems Director regarding integration of products into the Montana Drought Task Force Monitoring Program=92s World Wide Web site. This site is an established node on the National Spatial Data Infrastructure, and provides a rigorous model for metadata documentation and data content standards development as well as enhanced user access to traditional drought information (Palmer and SWSI Index maps) in conjunction with advanced EOS products.

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